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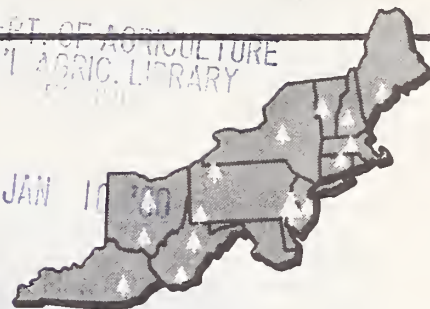
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RESULTS OF TREE AND SHRUB PLANTINGS ON LOW pH STRIP-MINE BANKS

—WALTER H. DAVIDSON

Research Forester
Northeastern Forest Experiment Station,
Princeton, W. Va.

Abstract. Test plantings were established to evaluate the survival and growth of trees and shrubs on 10 acid strip mines in the bituminous region of Pennsylvania. Included in the test were five species of European alder, four birch species, black locust, sycamore, Scotch pine, autumn olive, sawtooth oak, bristly locust, and Japanese fleecflower. After 11 years, data showed that two of the birches had highest rate of survival and best growth overall. On a few plots, European alder from a German seed source performed well. Scotch pine also performed well on a few plots. In general, survival and growth of all species was poor on spoils where the pH was less than 3.5.

Revegetation of low pH strip-mine banks has been a problem since reclamation of strip mines was first attempted. New legislation has reduced this problem on current mining operations. Pennsylvania strip-mine operators are now required to bury acid-producing overburden and spread topsoil on affected areas. Nevertheless, many acres of partially vegetated and unvegetated (orphan) banks remain from old mining operations. Low pH,

less than 4.0, is often cited as the reason why revegetation has failed. Federal legislation has provided funds to reclaim orphan banks. Some coal mining companies and private landowners are attempting to reclaim orphan banks without Federal assistance. However, recommendations for tree and shrub species to plant on low pH spoil banks are limited.

A study to test the performance of tree and shrub species on low pH spoil banks was

established in 1964. The study was limited to low pH spoils created by the surface mining of bituminous coal in Pennsylvania; 11-year results of the study are presented in this report.

THE STUDY

In the 1964 study in Pennsylvania, test plantings were established on 10 strip-mine areas in the bituminous region. Study sites were selected on the basis of low pH and failure of the original reclamation plantings. All areas had been backfilled, graded, and planted according to the 1945 Pennsylvania reclamation legislation. Five of the areas were overburden from mining the Clarion coal seam; two were from the Brookville, two from the Lower Kittanning, and one from the Middle Kittanning. Average pH values on these sites ranged from 3.1 to 3.6.

Sixteen species of trees and shrubs were used in this study (Appendix). In addition, three of the European alder species were represented by two or more seed sources. Study plots were designed to contain one row of 25 seedlings of each species. Seedlings were planted at a spacing of 2 feet within rows and with 6 feet between rows. At the time of planting, there were not enough seedlings of some species to conform to the planting design. Seedlings in short number were distributed among the study areas to have representation on each site. Test plantings were replicated twice on six sites, four times on three sites, and eight times on one site. Altogether, 14,205 seedlings were planted.

Individual test plots had a wide range of pH values; the value for soil samples collected from the 32 replicates ranged from 2.6 to 4.7, and 70 percent of the samples had a pH of 3.5 or lower.

Table 1.—Average survival of species planted on 10 low pH strip-mine banks in the bituminous region of Pennsylvania

Species	Number planted	Survival			
		1 yr	3 yr	5 yr	11 yr
		-----percent-----			
<i>Alnus incana</i> (France)	800	13	5	4	3
<i>Alnus incana</i> (Germany)	800	21	9	7	6
<i>Alnus viridis</i> (Corsica)	650	10	4	4	4
<i>Alnus viridis</i> (France)	800	10	2	2	2
<i>Alnus japonica arguta</i> (Japan)	170	27	13	5	4
<i>Alnus ihokumae</i> (Japan)	800	6	2	2	2
<i>Alnus glutinosa</i> (1495, Germany)	800	34	16	15	11
<i>Alnus glutinosa</i> (1489, Germany)	800	33	19	16	15
<i>Alnus glutinosa</i> (1793, Germany)	800	26	13	10	8
<i>Alnus glutinosa</i> (SCS)	80	30	15	13	2
<i>Betula lenta</i> (Pa.)	800	19	14	13	12
<i>Betula populifolia</i> (Pa.)	800	49	46	45	42
<i>Betula humilis</i> (Germany)	50	22	22	22	10
<i>Betula pendula</i> (Germany)	775	44	43	43	40
<i>Robinia pseudoacacia</i>	800	32	17	15	13
<i>Platanus occidentalis</i>	800	8	3	2	1
<i>Pinus sylvestris</i>	800	41	33	31	24
<i>Elaeagnus umbellata</i>	800	28	6	5	5
<i>Quercus acutissima</i>	800	52	13	13	12
<i>Robinia fertilis</i>	800	33	23	21	18
<i>Polygonum cuspidatum</i>	480	28	8	8	8

RESULTS

On the average, plant losses were quite high the first year; mortality by species ranged from 48 to 94 percent. On some sites, survival and growth seemed directly related to spoil pH. However, on other sites, there was little or no relationship between plant performance and pH. This suggests that other soil chemical and physical characteristics must be considered when selecting species for planting on low pH spoils.

The average survival rates (Table 1) show—except for birch—that most of the mortality occurs in the first 3 years. After the third year there was little additional mortality for most species but others continued to decline through the entire 11-year test period.

Average 11-year survival rates and height data are given by site in Table 2 for six of the species with the highest average survival. These data illustrate the variability in plant performance on different sites. Survival of all species was poor on the site with the lowest pH (3.1). As spoil pH increased, survival generally increased, but the relationship between average height and spoil pH was erratic. In the following discussion, planting recommendations for the various species are based on their performance at each of the planting sites. In this study, an average survival rate of 50 percent or greater was considered acceptable after 11 growing seasons.

Alders. In general, overall performance of the alders was poor. Eleven-year survival of one or more species exceeded 50 percent on only four plots on the 10 sites. All plots on which the survival rate was better than 50 percent had a pH of 3.5 or higher. After 11 years, 64 percent of the surviving alders were *Alnus glutinosa* from German seed sources.

It is recommended that *Alnus glutinosa* from German seed sources be planted on spoils that have a pH of 3.5 or higher.

Birches. Two species of birch (*Betula populifolia* and *B. pendula*) had the highest survival rates and best growth of all the species tested. These species had 50 percent or better survival on test plots at eight of the sites. The data suggest that the acid limit for these two species is about pH 3.3.

Table 2.—Eleven-year survival and average height of selected species planted on low pH strip-mine banks

Planting site ^a	Spoil pH	European alder ^b		Gray birch		European white birch		Scotch pine		Bristly locust		Sawtooth oak	
		Survival (%)	Height (ft)	Survival (%)	Height (ft)	Survival (%)	Height (ft)	Survival (%)	Height (ft)	Survival (%)	Height (ft)	Survival (%)	Height (ft)
Lower Kittanning I ^c	3.1	1	8	2	9	3	4	0	—	0	—	1	5
Middle Kittanning	3.1	1	6	13	20	11	21	5	10	1	1	2	8
Clarion I	3.3	5	6	75	16	62	15	44	8	27	2	15	4
Clarion II	3.3	3	4	42	19	52	21	16	8	14	2	6	10
Brookville I	3.4	17	11	38	17	54	17	24	7	28	10	12	10
Lower Kittanning II	3.4	38	18	79	18	66	17	42	7	10	8	3	5
Clarion III	3.4	3	4	68	15	48	18	42	9	12	1	16	6
Clarion IV	3.5	2	4	32	18	40	24	44	10	48	3	58	9
Brookville II	3.5	15	8	62	19	64	20	16	16	24	5	12	9
Clarion V	3.6	26	19	56	20	50	23	52	11	64	4	42	5

^aPlanting sites are named according to the coal seam that was mined.

^bData for European alder are based on survival and height of the three German sources of *A. glutinosa* combined.

^cOne replication on this site had a pH of 4.7; data from that replication are not included in the table.

Only 50 European white birch (*B. humilis*) were planted; after 11 years, 5 were alive. This number is too small to provide a good estimate of performance for this species.

Black birch (*B. lenta*) was heavily browsed by deer, a factor which greatly reduced survival. This species should not be planted if deer browsing poses a problem.

A recent study has shown that paper birch (*B. papyrifera*) performs as well as European white birch on problem spoils (1).

It is recommended that gray birch, European white birch, and paper birch be planted on spoils where the pH is 3.3 or higher.

Scotch pine. Performance of Scotch pine was highly variable. On four plots (pH 3.4 to 3.8), survival rates were among the highest observed in the study. Best height growth also occurred on plots in this pH range. On other plots in the same pH range, Scotch pine did not survive or grow well.

It is recommended that Scotch pine be planted on spoils where the pH is 3.5 or higher.

Bristly locust. Initial mortality was high. However, on plots where seedlings survived, the bristly locust is now spreading profusely by underground runners. On one plot, only a single seedling lived; but after 11 years, this plant has spread to cover an area of more than 300 square feet. On plots with living plants, sprouts are common at distances of 15 feet or more from the parent plants. Often, these sprouts are intermingled with other species in adjacent tree rows. Competition does not seem a problem and the additional nitrogen made available by the bristly locust probably benefits adjacent plants.

Survival after 11 years is more than 50 percent only on three plots (pH 3.4, 3.5, and 3.7). However, there were live plants on all plots (except one) that had a pH of 3.3 or higher.

It is recommended that bristly locust be planted on spoils with a pH of 3.3 or higher.

Sawtooth oak. Mortality of sawtooth oak was very high and performance was highly variable. Best results were obtained on spoils with a pH of 3.4, 3.5, and 3.7.

Sawtooth oak is not recommended for problem spoil plantings.

Black locust. Survival of black locust was quite variable. Only three plots (pH 3.6, 3.8, and 4.5) had survival of 50 percent or better. Height growth was also poor. Average height on the three best sites was 10.3 feet.

Black locust should not be planted on spoils with a pH below 3.5.

Sycamore. This species performed very poorly on all sites. Only 10 seedlings survived after 11 years.

Sycamore is not recommended for low pH spoils.

Autumn olive. This species performed poorly. Only one plot (pH 4.5) had a survival rate greater than 50 percent.

Autumn olive is not recommended for planting on highly acid sites.

Japanese fleecflower. Survival of this species was poor. However, on some sites (pH between 3.0 and 3.5) where one or more fleecflower survived, the plants have spread by natural seeding. Observations have shown that the spread of fleecflower is confined to open spoils. None has been observed in woodlands or grass areas adjacent to spoils.¹

Fleecflower is recommended only for spoils with a pH less than 4.0. On less acid spoils, more valuable species are available for reclamation planting.

SUMMARY

Average survival for all species in the study was low. Some species performed better than others and can be recommended for planting on acid spoils, pH 3.5 and higher. Survival of the more acid tolerant species was unpredictable on sites with a pH lower than 3.5.

Birches performed better than other species tested. Gray birch and European birch (*B. pendula*) were the best. Deer and rabbit browsing posed a problem on the black (sweet) birch. Thus, gray birch and European birch (*B. pendula*) are recommended for Pennsylvania bituminous spoils with a pH of

¹Balogh, Richard. 1978. An investigation of Japanese fleecflower (*Polygonum cuspidatum*) planted on two bituminous strip-mine spoils in Pennsylvania. Unpublished Master's thesis, Clarion State College, Clarion, Pa.

3.5 or higher. At a lower pH these species may be acceptable if other spoil characteristics are not limiting. If pH or other spoil characteristics are limiting, then the application of ameliorating amendments is necessary to establish suitable planting sites.

LITERATURE CITED

Davidson, Walter H.

1977. **Birch species survive well on problem coal mine spoils.** In Proceedings 24th Northeastern forest tree improvement conference. Univ. Md., College Park. p. 95-101.

APPENDIX

Species Tested on Low pH Strip-mine Banks

European alder (*Alnus incana*), French seed source
European alder (*Alnus incana*), German seed source
European alder (*Alnus viridis*), Corsica seed source
European alder (*Alnus viridis*), French seed source
European alder (*Alnus japonica arguta*)
European alder (*Alnus ihokumae*)
European alder (*Alnus glutinosa*), German seed source #1495
European alder (*Alnus glutinosa*), German seed source #1489
European alder (*Alnus glutinosa*), German seed source #1793
European alder (*Alnus glutinosa*), SCS seed
Black (sweet) birch (*Betula lenta*)
Gray birch (*Betula populifolia*)
European white birch (*Betula humilis*)
European white birch (*Betula pendula*)
Black locust (*Robinia pseudoacacia*)
Sycamore (*Platanus occidentalis*)
Scotch pine (*Pinus sylvestris*)
Autumn olive (*Elaeagnus umbellata*)
Sawtooth oak (*Quercus acutissima*)
Bristly locust (*Robinia fertilis*)
Japanese fleecflower (*Polygonum cuspidatum*)

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